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SOURCE Avtomobil', No 6 1951.TESTING THE SOVIET NAMI-012 STEAM-POWERED TRUCKN. Korotonoshko
Cand Tech Sci

The steam-powered truck has considerable advantages over trucks with internal combustion engines; the main advantage is that it can operate on cheap, local, hard fuels such as wood, peat, or coal, thus reducing the cost of transporting freight. The advantages of the steam-powered truck over the gas-generator truck are its exceptional dynamic qualities and greater reliability in operation.

NAMI (Scientific-Research Automobile and Automobile Motor Institute) has developed the 5-6 ton NAMI-012 steam-powered truck, basing it on the YAZ-200 truck.

The three-place cab is located over the truck's front axle. The machine compartment, holding all the mechanisms of the steam power plant including the engine, auxiliary equipment, and the boiler unit, is located behind the cab. Behind the boiler is the freight platform or the coupling for trailers.

The truck is equipped with a three-cylinder, single-expansion, bilateral-pressure, reversing engine, with the cylinders in a vertical position.

The water-tube steam boiler has a superheater, natural circulation, and an economizer for preheating the water. The fuel hoppers are loaded with wood which descends into the combustion zone by gravity feed as the old wood is burned up.

The steam power plant also includes a steam condenser, a fan for cooling the condenser, an air blower for the firebox, a turbine for driving the condenser fan and the air blower, and electric starting motor, and an ejector pump for filling the tank with water.

The turbine for operating the condenser fan and the air blower is run on waste steam, the pressure of which is directly proportional to the load on the steam engine. When the pressure of the exhaust increases, the turbine speeds up, increasing air feed to the boiler. Thus, the steam productivity of the boiler is increased automatically when the engine is working under increased loads or speeds.

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Road tests of the steam-powered truck on a run of 12,000 kilometers showed that its steam power plant was reliable, economical, and could be operated by the driver alone. The truck gave good results with a load of 6 tons and also in hauling trailers with a total weight of 23 tons.

The dynamic qualities of the truck were evaluated by determining the maximum speed and rate of acceleration with various loads. The results of measuring maximum speeds are given in the following table:

<u>Load</u> (tons)	<u>Crankshaft Rpm.</u>	<u>Max Speed</u> (km/hr)
6	1,212	42.35
12 (with trailer)	1,150	40.00

Maximum average effective speed in a 100-kilometer highway trip without a trailer was 40.2 kilometers per hour, and average speed for the whole trip was 30 kilometers per hour. Average speed with a trailer (total weight of truck and trailer 23 tons) for a distance of 165 kilometers was 30.4 kilometers per hour.

In driving along the open highway a clutch in the transmission makes it possible to increase average speed by using free wheeling. Average operating speed of the steam-powered truck was 24.3 kilometers per hour, and time spent servicing the truck en route made up 19 percent of the total operating time.

All acceleration tests took place from standstill with the engine turned off. Under these conditions, the engine started faultlessly at the first touch of the starter. The tests showed that the steam-powered truck has good capacity for acceleration up to 27 kilometers per hour, after which acceleration is hindered by inadequate power transmission at high engine speeds. However, the following table shows that the NAMI-012 has good dynamic qualities:

<u>Truck</u> <u>Tested</u>	<u>Working</u> <u>Load</u> (tons)	<u>Total</u> <u>Wt</u> (kg)	<u>Final</u> <u>Speed</u>	<u>Acceleration</u> <u>Time</u> (sec)
NAMI-012 without trailer	6.0	11,344	16 32	4.0 14.2
NAMI-012 with trailer	12.0	23,000	16 32	7.2 22.5
YAZ-200 without trailer	7.0	13,500	16 32	5.8 17.0
YAZ-200 with trailer	13.0	23,000	16 32	10.0 32.5

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It must be kept in mind that the design of the YAZ-200 truck has been completely developed and put into series production while the NAMI-012 truck is only an experimental model.

An important advantage of the steam-powered truck is the increase in the torque of the engine as the number of revolutions per minute decreases. This raises the tractive force on the wheels without shifting gears. The NAMI-012 steam engine develops a maximum torque of 240 kilogram-meters, five times that of the YAZ-200 motor, even though the nominal power of both motors is practically the same.

In evaluating the dynamic characteristics of the steam-powered truck, it must be kept in mind that an increase in the tractive force, brought about by a considerable increase in torque, is accompanied by greater specific steam consumption when operating at high degrees of loading, which in turn increases specific fuel consumption.

It is difficult to measure wood consumption of a steam-powered truck in relationship to speed, since it takes from 2 to 5 hours for the wood in the hopper to burn out. Considerable variations in the type and moisture content of woods, especially in summer, have a significant influence on wood consumption.

The steam-powered truck travels 80-100 kilometers on one filling of the hopper; thus it consumes 3-4 kilograms of wood having a moisture content of 30-33 percent per kilometer.

The following table gives comparative fuel-consumption indexes of gasoline, gas-generator, and steam-powered trucks on the basis of available data. In determining the relative costs of wood blocks and firewood, it was assumed that one cubic meter of wood blocks cost four times as much as one cubic meter of firewood.

<u>Type of Vehicle</u>	<u>Gasoline</u>	<u>Gas-Generator</u>	<u>Steam-Powered</u>
Relative cost of ton of fuel	1.0	0.4	0.1
Fuel consumption per 100 km (kg)	30.0	100.0	400.0
Working load of trucks compared (tons)	4.0	2.5	6.0
Fuel required to move one ton 100 km (kg)	7.5	40.0	66.6
Relative cost of moving one ton 100 km	100.0	21.0	89.0

Although the coefficient of efficiency of the steam power plant is considerably lower than that of an internal combustion engine, wood consumption of the steam-powered truck per ton per 100 kilometers is only 1.66 times that of the gas-generator truck. At the same time, it must be kept in mind that wood for gas-generator trucks must be twice as dry as for steam-powered trucks. However, it is not fair to compare steam-powered and gas-generator trucks in this way since they both make it possible to save liquid fuel, and both have their advantages and disadvantages.

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The problem of supplying the boiler with water is a serious one since heavy water consumption shortens the distance between refueling stops and hastens the formation of boiler scale on the steam preheater, the economizer, and the working surfaces of the boiler.

The outside temperature has a lot to do with water consumption, as do the manner of driving the truck, the forcing capacity of the steam power plant, and the presence of leaks.

Average water consumption of the NAMI-012 is 100-150 kilograms per 100 kilometers, or 40-50 kilograms per hour. The truck has a 200-liter water tank, enough for 100-150 kilometers of travel. The low water consumption of the steam power plant is achieved by reduced specific consumption of steam by the engine and an efficient condenser set up.

Two means of firing the boiler were used in the tests: a blower and natural draft, with the following results:

<u>Means of Firing</u>	<u>Firing Time to Starting of Turbine (min)</u>	<u>Time to Get up 12 Atm of Steam (min)</u>	<u>Time to Get up 24 Atm of Steam (min)</u>	<u>Consumption of Firewood (kg)</u>
Using blower	15-20	25-30	30-40	40-50
Using natural draft	25-30	35-40	40-50	40-50

The experiments showed that the steam-powered truck could start at a boiler pressure of 10-12 atmospheres and then develop normal boiler pressure while operating. There is a wide range of tractive force and speeds at the driver's disposal, so the necessity for hand shifting of steam loading is rare. The driver must observe the water level in the boiler while driving and regulate it by means of a remote control indicator. Pressure changes in the boiler occur gradually while driving under changing loads since the steam power plant automatically changes the rate of combustion. Fuel feed is automatic and does not require the driver's attention. Periodic filling of the truck with water and fuel takes two men 7-10 minutes. However, one man can operate the truck alone.

Road tests proved conclusively that the NAMI-012 steam-powered truck has good dynamic qualities and sufficient roadability, is economical, and is sufficiently maneuverable for a truck of its class.

Technical Characteristics

Working load (tons)	5-6
Weight of fueled truck, unloaded (kg)	8,344 (weight of YAZ-200 is 6,500 kilograms)
Weight of truck with load of 6 tons	14,344
Load on front axle (%)	32.1
Load on rear axle (%)	67.9
Length of truck (mm)	7,690
Width of truck (mm)	2,650
Maximum height (mm)	2,677
Wheel base (mm)	4,520
Track of front wheels (mm)	1,920

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Clutch	Dry, three-disk
Transmission	Two-speed, i_1 equals 1, i_2 equals 2.22
Gear ratio of main transmission	5.96
Maximum speed (km/hr)	42
Type of steam power plant	Closed, with condensation of the steam
Boiler pressure (atm)	25
Superheating temperature (deg C)	400
Boiler capacity at normal level (liters)	140
Fuel	Firewood, 500 x 100 x 100 mm
Weight of assembled boiler (kg)	1,200
Capacity of fuel hopper (cu m)	0.75
Cylinder diameter and stroke (mm)	125 x 125
Effective horsepower of engine at 900 revolutions per minute	100
Maximum crankshaft rpm	1,250
Maximum torque at 80-100 rpm (kg m)	240
Weight of the steam engine (kg)	700

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